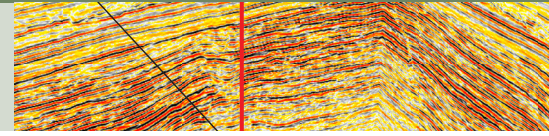


# Hydrocarbon potential of the offshore northern Perth Basin

*New data and knowledge deliver opportunities for petroleum explorers*

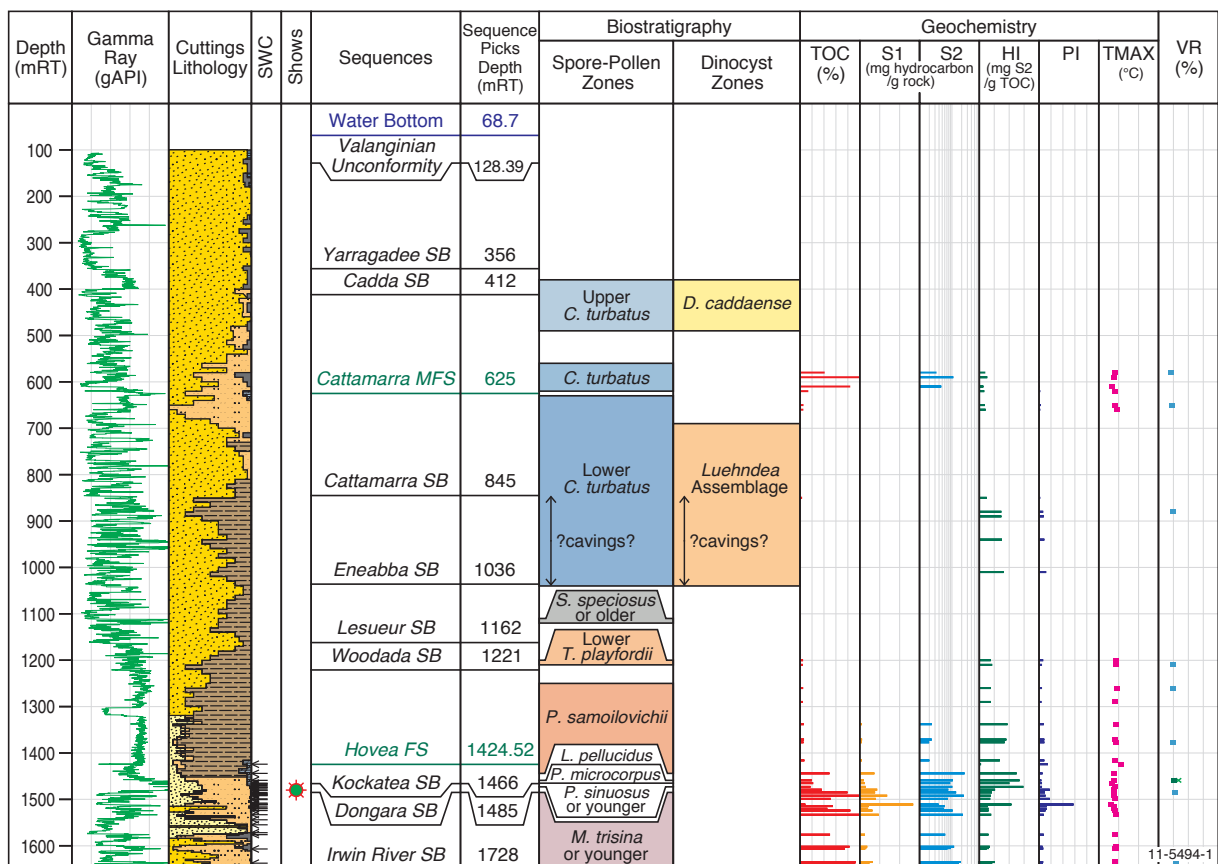


*Andrew Jones, Diane Jorgensen, Ron Hackney and Chris Nicholson*

Geoscience Australia has recently completed an assessment of the hydrocarbon prospectivity of the offshore northern Perth Basin to stimulate exploration in the basin by Australia's offshore oil and gas industry. The study was mainly based on new data collected as part of Geoscience Australia's Offshore Energy Security Program. A review of the Program is included in this issue of *AusGeo News*.

The new datasets, including regional two-dimensional (2D) and three-dimensional (3D) seismic, potential field and well data, provided an improved understanding of basin evolution and the spatial distribution of key petroleum system elements. The new

knowledge generated during this study has enhanced the potential for new oil and gas discoveries in the Perth Basin. It also underpinned the release of area W11-18 in April 2011 as part of the Australian Government's 2011 release of offshore petroleum exploration acreage (see *AusGeo News* 102).



**Figure 1.** An example of the data included in the Dunsborough-1 well composite from the offshore northern Perth Basin well folio (location shown in figure 4). The Middle Jurassic to Permian stratigraphy in Dunsborough-1 was revised on the basis of sequence stratigraphic analysis that incorporated a review of open-file palynological data and new palynological analysis of cuttings samples over the interval 380-1210 mRT. Forty-one new geochemistry and 10 new Vitrinite Reflectance measurements were acquired from cuttings and side wall core samples over the interval 580-1725.4 mRT.

Oil is currently being produced from the offshore northern Perth Basin, specifically from the Cliff Head oil field that was discovered in 2001. Three more petroleum discoveries were made in this part of the basin in 2007, with oil and gas in Dunsborough–1, and gas in Frankland–1 and Perseverance–1. These accumulations are located in Permian sandstones and have primarily been sourced from the Triassic Hovea Member of the Kockatea Shale. This shale has also been the source of the majority of producing oil and gas fields of the onshore Perth Basin.

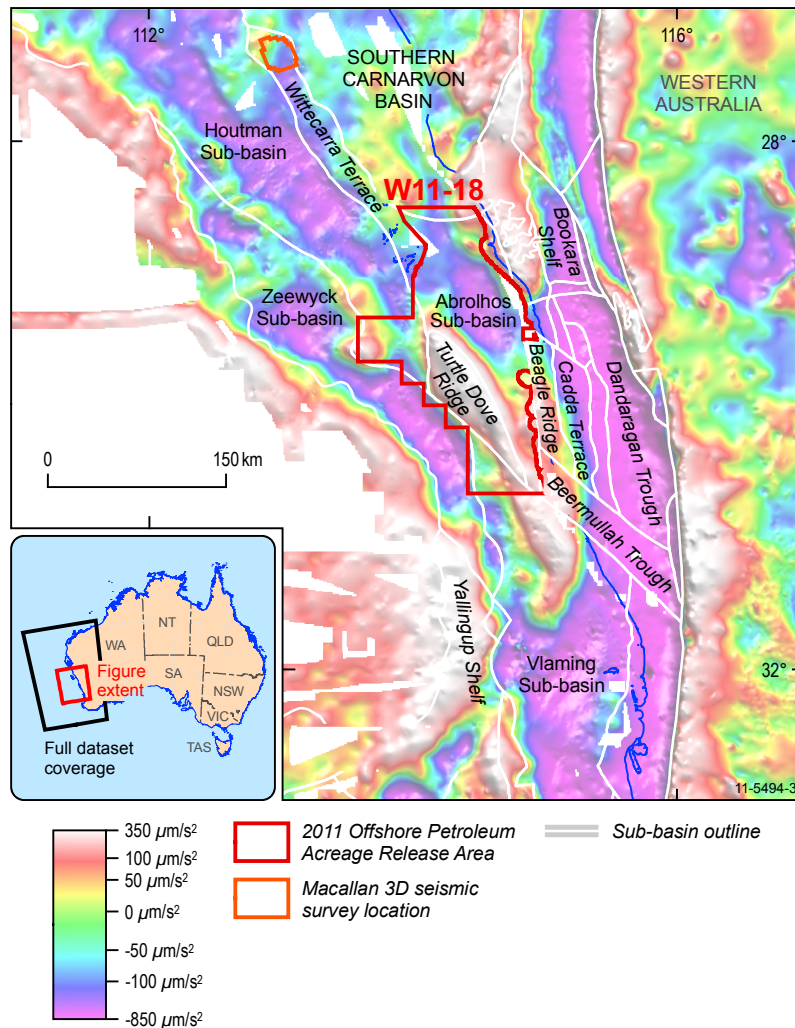
## Depositional history

The biostratigraphic history of the offshore northern Perth Basin was revised through combining existing well data with interpretations of newly-acquired palynology data. This study also included the first published synthesis of data from 14 new exploration wells drilled

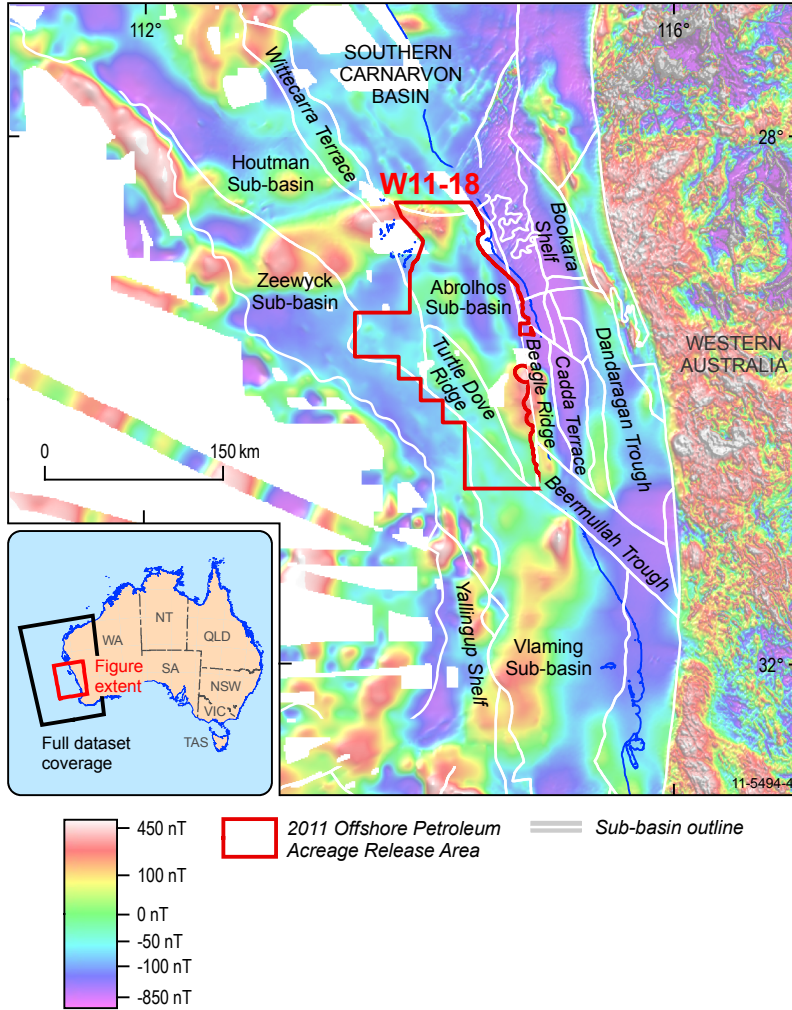
since the Cliff Head–1 discovery.

The new biostratigraphic data were reviewed and used in conjunction with well logs and lithological interpretations of cuttings, cores and sidewall cores to define a new chronostratigraphic sequence framework. Depositional sequences and key maximum flooding surfaces are correlated between wells to show the spatial and temporal distribution of these sequences. The main sedimentary succession in this part of the basin is Permian to Late Jurassic in age. Two regional unconformities were identified and they correspond to regional uplift in the Late Permian (Capitanian) and the breakup of Australia and Greater India in the Valanginian Stage.

The new data and interpretations for 23 of the petroleum exploration wells are included in the offshore northern Perth Basin well folio (figure 1). These new data include: 120 new palynological samples; 244 new geochemistry measurements; 100 new thermal maturity measurements; and a compilation of Grains with Oil Inclusions (GOI™) data. All data presented in the folio were either publicly available or newly derived. The composite 1:5000 scale well log summarises, in graphic form, the main stratigraphic features and hydrocarbon occurrences (figure 1). The folio also includes Offshore Perth Basin Biozonation and Stratigraphy 2011 Chart 38.



**Figure 2.** The levelled and merged gravity dataset for the northern Perth Basin and adjacent onshore areas overlain by structural elements of the offshore northern Perth Basin and the Release Area W11-18. The residual gravity image is computed from the Bouguer anomaly by subtracting its upward continuation to 25 kilometres.



**Figure 3.** The levelled and merged, reduced-to-pole magnetic dataset for the northern Perth Basin and adjacent onshore areas overlain by structural elements of the offshore northern Perth Basin and the Release Area W11-18.

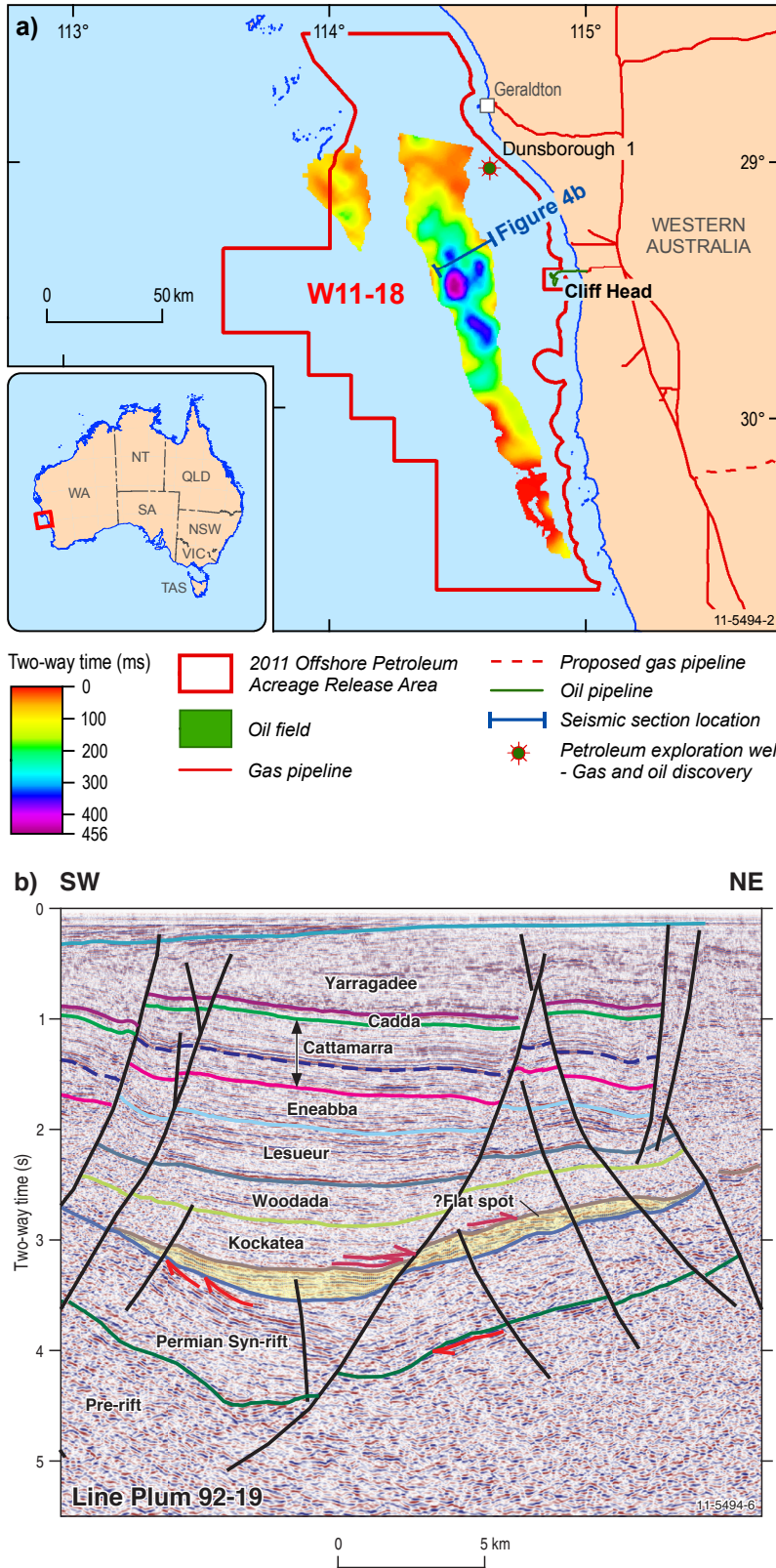
### New geophysical datasets

A major output from the study is a data package which includes reprocessed seismic data, new seismic reflection data and new gravity and magnetic data. The new seismic, gravity and magnetic datasets were collected between October 2008 and February 2009 during two major surveys off the coast of Western Australia (surveys GA-310 and GA-2476). The datasets collected during these surveys have greatly improved the coverage over a large portion of Australia's southwestern margin. The data package covering this area was released to the petroleum industry by the Australian Government's Minister for Resources and Energy, the Hon Martin Ferguson AM MP, in April 2010.

The new gravity and magnetic data were merged and levelled with an existing Australia-wide dataset (Petkovic et al 2001) and combined with onshore data from the fifth edition of the Magnetic Anomaly Map of Australia (Milligan et al 2010) and the 2010 version of the

Australian National Gravity Database. The final compilations of gravity and magnetic data provide a consistent dataset that covers the southwestern margin of Australia (106–120°E and 19–37°S). This area includes the Mentelle, Perth and southern Carnarvon basins, as well as the Wallaby Plateau. Data covering the northern Perth Basin (figures 2 and 3), as well as the full dataset coverage of the area, are available for download through the Geophysical Archive Data Delivery System (see below).

The new compilations of levelled gravity and magnetic data covering marine and onshore areas are facilitating structural and geological interpretations of the offshore northern Perth Basin. Depth-to-basement and basement architecture in some parts of the basin are not well defined using seismic data. For these locations integrated modelling and interpretation of potential field data are being used to provide additional information. Several geophysical processing methods are being applied to the new datasets, including wavelet-based multi-scale edge detection to highlight the edges of anomalies. This method complements seismic reflection data for mapping structural trends. Spectrally-based depth-to-basement estimates and three-dimensional (3D) gravity modelling are being used to map basement architecture.



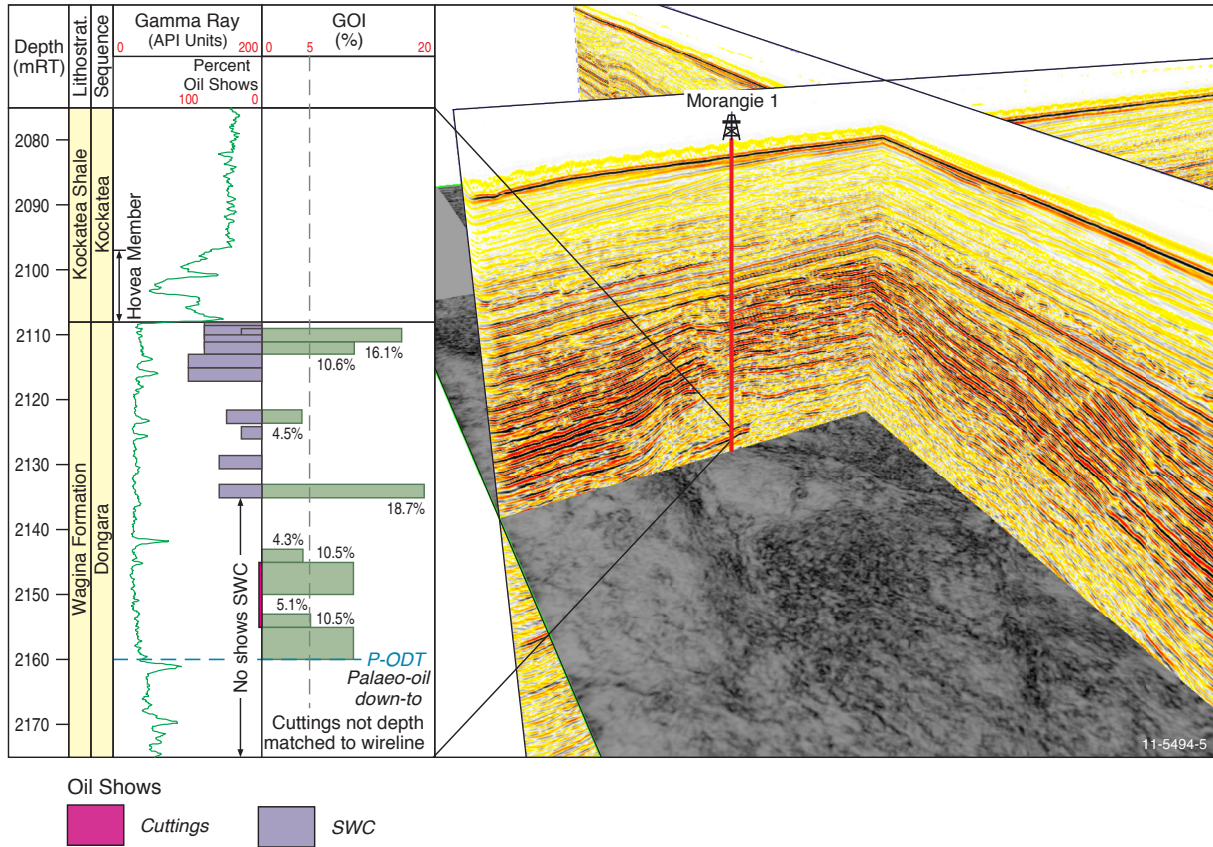
**Figure 4a.** The thickness and spatial distribution of a potential, large upper Permian stratigraphic play identified within Release Area W11-18.  
**b.** Portion of seismic line Plum92-19, in the Abrolhos Sub-basin, displaying a thick basal succession of high amplitude continuous reflectivity interpreted as a potential reservoir. Hydrocarbons may have been preserved within this unit, when structural accumulations were breached through tectonic reactivation.

## Petroleum prospectivity assessment

The new seismic data collected by Geoscience Australia show that Permo-Triassic strata which are stratigraphically equivalent to the productive onshore and nearshore Perth Basin petroleum system also occur within Permian half-grabens in the outer Abrolhos and Houtman sub-basins. Source rock, oil stain and fluid inclusion sampling from these strata indicate that the proven onshore-nearshore petroleum system is also effective and widespread offshore. There is also evidence for an active Jurassic petroleum system within the W11-18 Release Area. This assessment of petroleum prospectivity (Jones et al 2011) underpinned the release of offshore petroleum exploration area W11-18 in April 2011.

## Reducing exploration risk

A major exploration risk in the offshore northern Perth Basin is loss of petroleum accumulations because of trap breach. In a joint CSIRO and Geoscience Australia collaborative study, palaeo-oil columns were detected in Permian reservoir sandstones below the Kockatea Shale regional seal in 13 of the 17 wells from the Abrolhos Sub-basin that were analysed. Further outboard, a palaeo-oil column in Houtman-1 demonstrates an effective oil-charge system in Jurassic strata in the Houtman Sub-basin. Breach



**Figure 5.** 3D seismic will be interpreted in 3D visualisation mode around prospects with oil-charge indicators (fluid inclusion GOI™) to aid understanding of the breached trap mechanism via later modelling. The Macallan 3D seismic data set is shown with vertical slices showing amplitude (red and yellow) and horizontal slices showing variance (shades of grey). The GOI™ log for Morangie-1 is reproduced from Kempton et al (2011).

of palaeo-accumulations in the offshore northern Perth Basin could be attributed to fault reactivation and structuring associated with Valanginian breakup, the tilting of the margin following the breakup, or inversion of faults during the Miocene (Kempton et al 2011).

Stratigraphic plays, which can accumulate and preserve hydrocarbons away from faults, were identified to address the risk of trap breach. A potential, large upper Permian stratigraphic play occurs within two depocentres (or areas of thick sediments) within Release Area W11-18 (figure 4a). These depocentres contain a thick basal unit with high seismic amplitudes and continuous reflectivity, which is overlain by the Kockatea Shale regional seal (figure 4b). Petroleum systems modelling indicates this potential reservoir was well positioned to receive oil-charge from the overlying Hovea Member.

A collaborative trap integrity study between CSIRO and Geoscience Australia, is underway and will focus on several drilled prospects which are covered by 3D seismic data and contain both breached and preserved oil columns (Kempton et al 2011; figure 5). Three-dimensional coupled deformation and fluid-flow numerical modelling will be used to simulate the response of trap-bounding

faults to extensional reactivation in these prospects and therefore investigate hydrocarbon preservation risk in the Abrolhos Sub-basin.

### References

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Petkovic P, Fitzgerald D, Brett J, Morse M & Buchanan C. 2001. Potential Field and Bathymetry Grids of Australia's Margins. ASEG Extended Abstracts 2001 (1).

### **For more information**

**email** [ausgeomail@ga.gov.au](mailto:ausgeomail@ga.gov.au)

### **Related articles/websites**

Geophysical Archive Data Delivery System (GADDS)

[www.geoscience.gov.au/bin/mapserv36?map=/public/http/www/geoportal/gadds/gadds.map&mode=browse](http://www.geoscience.gov.au/bin/mapserv36?map=/public/http/www/geoportal/gadds/gadds.map&mode=browse)

Australian National Gravity Database

[www.ga.gov.au/minerals/projects/current-projects/continental-geophysics/gravity.html#afgn](http://www.ga.gov.au/minerals/projects/current-projects/continental-geophysics/gravity.html#afgn)

Frontier Basins of the West Australian Continental Margin: Post-survey Report of Marine Reconnaissance and Geological Sampling Survey GA2476 (Geoscience Australia Record 2009/38)

[https://www.ga.gov.au/products/servlet/controller?event=GEOCAT\\_DETAILS&catno=69606](https://www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=69606)

Offshore northern Perth Basin well folio (Geoscience Australia Record 2011/09)

[https://www.ga.gov.au/products/servlet/controller?event=GEOCAT\\_DETAILS&catno=71568](https://www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=71568)

*AusGeo News* 102: The 2011 Acreage Release for offshore petroleum exploration

[www.ga.gov.au/ausgeonews/ausgeonews201106/acreage.jsp](http://www.ga.gov.au/ausgeonews/ausgeonews201106/acreage.jsp)

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